DSN Telemetry Predicts Generation and Distribution

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The DSN Telemetry System Analysis Group is responsible for generating and/or disseminating the predicted uplink signal levels at the spacecraft, and the predicted downlink signal levels at the Deep Space Stations. Also included in the predictions are the telemetry signal-to-noise ratios. Two different Univac 1108 programs are used to generate these data. The JPL spacecraft-oriented predicts are generated by the Telecommunications Prediction and Analysis Program. The non-JPL spacecraft-oriented predicts are generated by the DSN Telecommunications Prediction Program which is operated by the Telemetry Group of the Network Analysis Team (NAT TEL). These predicts are distributed throughout the DSN and to specified project personnel.

I. Introduction

The generation and distribution of telemetry signal-to-noise ratio (SNR) and signal-level predictions are handled by nonreal-time analysts in the NAT TEL Group. These predicts are generated in the Univac 1108 computer by use of station, spacecraft, trajectory, and range parameters. The predicts are distributed to all interested parties on a scheduled basis.

II. Usage

The real-time analysts in NAT TEL modify the predicts to conform to any change in the spacecraft or DSN configuration/parameters, and use them to calculate the residual signal levels and SNRs of the station which is being operated. From these residuals the analysts can determine if the tracking station is within a specified tolerance, and can perform troubleshooting analysis where required.

The nonreal-time analysts in NAT TEL use the predicts and residuals to perform long-term trend analysis. The residuals are compiled and various measures of statistical variation are computed by another Univac 1108 computer program developed by the NAT TEL Group.

All active tracking stations are on distribution. The station personnel use the predicts to help determine the accuracy and performance of their systems.

The Operations and Engineering Groups of the Deep Space Instrumentation Facility (DSIF) use the predicts for long-term trend analysis work to enhance the performance of the tracking stations.

The DSN Project Managers are on distribution in order to perform quick-look analyses.

Project personnel are also on distribution to help determine the health of their spacecraft, the mission operational limitations, and spacecraft mode feasibilities.

III. Generation

The JPL spacecraft-oriented predicts are received from Project personnel and are modified, as required, by NAT TEL. They are then distributed by standard teletype (TTY) methods.

For non-JPL spacecraft, the Receiver and Telemetry SNR Predictions Program has been updated and changed to the DSN Telecommunications Prediction Program and is now being used for *Pioneers 6* through *10*. With slight modifications and Project-supplied parameters, this program can be used for any mission.

The following information shows the different parameters and computations that are used to generate the DSN Telecommunications Prediction Program.

A. Identification Input

The ID card provides the following inputs:

(1) Modulation index

(2) System noise temperature

(3) Receiver bandwidth

(4) Polarizer in or out

(5) 26- or 64-meter network

(6) Spacecraft number

(7) Month to start predicts

(8) Year to start predicts

(9) Pass number to start predicts

(10) Number of days to run predicts

(11) Mission [Ground Operational Equipment (GOE) or Multiple-Mission Telemetry (MMT)]

(12) Cone in use [S-Band Cassegrain Monopulse (SCM), Polarization Diversity S-Band (PDS), S-Band Megawatt Transmit (SMT) or S-Band Polar Ultra (SPU)]

(13) Transmitter power

(14) Downlink bias

(15) Uplink bias

B. Data Input

Data input is by cards providing day of year and spacecraft range in kilometers. The range data are obtained from the spacecraft trajectory printout [Double-Precision Trajectory Program (DPTRAG)].

C. N and FIN Card Input

The N card provides the number of range values to be input to the program. The FIN card is used to signal a new run or termination of the program.

D. Range Interpolation

The program uses a four-point Lagrange interpolation routine. The day of year and spacecraft range are input to the program and interpolated to provide range for daily computations. The program will take up to 99 inputs and can compute predicts for 999 days.

E. Prediction Computations

The equation for free-space loss is

$$L_{fs} = 92.45 + 20 \log (f) + 20 \log (d)$$

where

L_{fs} = free space loss in decibels

f = received frequency in GHz

d = spacecraft range in kilometers

The predicted received signal strength is computed as follows:

SS = (spacecraft gain) + (ground antenna gain) − (modulation loss) − L_{fs} − (antenna pointing loss = 0.5 dB)

where

Spacecraft gain for:

Pioneer 6 = +48.9 dB

Pioneer 7 = +48.2 dB

Pioneer 8 = +49.1 dB

Pioneer 9 = +49.1 dB

Pioneer 10 = +70.4 dB

Ground antenna gain for:

26-m antenna = + 53.3 dB

64-m antenna = +61.4 dB

Modulation loss is 20 log cos (modulation index)

Modulation index for PN 6 through 9 = 51.6 deg or 0.9 rad

Modulation index for PN 10 = 63.03 deg or 1.1 rad

The receiver margin is computed by

$$M = SS - 10 \log T_s - 10 \log BW + 198.6$$

The ST_b/N_o of the telemetry is computed by

$DPWR$ = total gain − L_{fs} + 20 log sin (modulation index)

$$SNR = DPWR - 10 \log T_s - 10 \log BR - \text{loss} + 198.6$$

where

M = receiver margin in dB

$DPWR$ = telemetry data power in dB

SS = predicted receiver signal strength in dBm

SNR = telemetry ST_b/N_0

K = Boltzman constant (−198.6 dBm)

BR = bit rate

T_s = system noise temperature in kelvin

BW = receiver bandwidth in hertz

Loss = fixed system loss depending on bit rate and mode (MMT or GOE)

The predicted uplink signal strength is computed as follows:

$$UL = P_{out} + \text{spacecraft gain} + \text{ground antenna gain} - L_{fs}$$

where

Spacecraft gain for:

Pioneer 6 = −8.6 dB

Pioneer 7 = +9.2 dB

Pioneer 8 = +9.9 dB

Pioneer 9 = +8.6 dB

Pioneer 10 = +9.1 dB (medium gain)

Pioneer 10 = +28.5 dB (high gain)

Ground antenna gain for:

26-m antenna = +51.8 dB

64-m antenna = +60.5 dB

P_{out} = 10 log (TXP/ 0.001)

TXP = ground transmitter power

IV. Future Methods

At this time the only method of transmitting telemetry predicts is via teletype (TTY). In the near future capability will exist for all JPL spacecraft-oriented predicts to be transmitted via High-Speed Data Line (HSDL) as well as TTY. This will be done by using a different Univac 1108 computer program, which will format a magnetic tape to be used on the IBM 360/75. The 360/75 will transmit the predicts to the stations and other specified areas by use of the on-line operational program.